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RESEARCH LITERACY, SOCIO-SCIENTIFIC REASONING, AND PROBLEM-SOLVING SKILLS IN SCIENCE TEACHERS

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Abstract. *This research is a comprehensive mixed-methods study that aims to examine in depth the correlations between science teachers' research literacy, socio-scientific reasoning, and problem-solving skills. The quantitative phase of the research was conducted using a descriptive survey method, while the qualitative phase employed a case study design. The study population consists of science teachers working in the central districts of Konya, and Türkiye. For sample selection, stratified and random sampling techniques were used for the quantitative data, and purposive sampling techniques were applied for the qualitative data. Confirmatory factor analysis and reliability analyses were conducted using the three different measurement tools used in the study. A semi-structured interview form was utilized to collect qualitative data. The quantitative findings revealed that research literacy and socio-scientific reasoning skills significantly and positively predict problem-solving skills. The qualitative findings indicated that these skills mutually reinforce each other, enhancing students' scientific and analytical thinking capacities and enabling them to develop creative solutions to real-life problems. In this context, the evidence presented indicates that educational policies should focus on fostering these skills through a comprehensive approach, with greater emphasis on integrating innovative methods into science curricula.*

Keywords: *mixed methods research, problem-solving, research literacy, science teachers, socio-scientific reasoning*

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Introduction

Today's education systems aim to educate students with the skills required by the information age. In line with this purpose, it aims to develop students' competencies in accessing, evaluating, and using information by providing them with research literacy; to gain a critical and ethical perspective on scientific and social issues with socio-scientific reasoning skills; and to enable them to produce creative and analytical solutions to complex problems they encounter with problem-solving skills. Especially in this respect, science education stands out as an important discipline that contributes to the development of students' critical thinking (Adams, 2024), scientific inquiry (Seher Budak & Defne Ceyhan, 2023), problem-solving and socio-scientific reasoning skills (Gillies, 2024). In this context, it is critical for science teachers to have these skills (Herranen & Aksela, 2019) and to effectively reflect these competencies in teaching processes (Johnson, 2024). However, when the existing literature is examined (Filho et al., 2024; Heikkilä & Eriksen, 2023; Muchlas Abrori et al., 2023), it is seen that the correlations between science teachers' research literacy, socio-scientific reasoning, and problem-solving skills have not been systematically addressed and there is a significant research gap in these areas. Research literacy refers to teachers' ability to access scientific knowledge (Beaudry & Miller, 2016), critically evaluate this knowledge (McGregor, 2018), and use this knowledge in the classroom environment (Shank et al., 2018). This skill is essential for teachers to keep up with constantly changing and updated scientific knowledge (Menard, 2003) and to guide their students in this direction (Davis, 2008). Similarly, socio-scientific reasoning refers to students' capacity to think analytically and make logical inferences on scientific issues (Filho et al., 2024), including environmental, ethical, and social dimensions (Karukstis & Elgren, 2007). This directly affects teachers' ability to discuss complex socio-scientific issues in the modern world with students (Knain, 2015). Problem-solving skill, on the other hand, enables teachers to develop creative solutions to the problems they encounter in their professional lives (Rizvi, 2024) and to provide this skill to students (Musa, 2024).

Literature Review

Addressing the correlation between research literacy, socio-scientific reasoning, and problem-solving skills through theoretical approaches and

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theories offers an in-depth perspective in terms of education and scientific thinking. Research literacy includes students' ability to access, evaluate, and apply scientific knowledge (Shank & Brown, 2007). In terms of research literacy, information processing theory provides a basic approach to explain this process (Bettman, 1979). According to this theory, students go through the processes of perceiving, processing, storing, and recalling information (Kmetz, 2018). Effective management of these processes strengthens research literacy (Bettman, 1979). Socio-scientific reasoning is the ability of students to solve problems (Shah, 2019) by using scientific knowledge in a social context (Uyanık, 2024). This process can be explained by Lev Vygotsky's socio-cultural theory. Vygotsky has emphasized the role of social interactions and cultural tools in students' cognitive development (Garg, 2023). Socio-scientific reasoning involves students making decisions by taking into account social and ethical values and this process is enriched by social interactions (Fındık, 2024). Vygotsky's concept of the zone of proximal development states that students can learn more complex tasks in interaction with others, and this plays a critical role in the development of socio-scientific reasoning (Garg, 2023). Problem-solving skills refer to students' ability to identify (Wallace et al., 2013), analyze (Sinha, 2020), and solve the problems they face (Attri, 2018). Gestalt theory offers an important perspective on the problem-solving process. This theory states that students try to solve problems from a holistic perspective, not by breaking them into parts (Wertheimer & King, 2005). In the problem-solving process, it is important for students to find solutions by mentally restructuring (Petermann, 2013). This enables students to adapt their existing knowledge and experiences to new situations (Wertheimer & King, 2005). Furthermore, this theoretical framework shows how research literacy, socio-scientific reasoning, and problem-solving skills interact and support each other. Research literacy strengthens students' ability to understand, evaluate, and apply scientific knowledge (Sambey, 2016). This knowledge gains meaning in the social context to be used in socio-scientific reasoning processes (Abell, 2007). Socio-scientific reasoning enables students to make more in-depth and informed decisions (Powel, 2021) by using scientific knowledge in a social and ethical context (Sadler, 2021). Problem-solving skills, on the other hand, allow students to approach the problems they face from a holistic perspective (Beghetto, 2018) and produce effective solutions (Zheng, 2023). This process requires students to adapt their existing knowledge and experiences to new situations through mental restructuring (Hiremath, 2024). Research literacy, socio-scientific reasoning, and problem-solving skills are important skills that interact with each other (Shank et al., 2018) and contribute to students' more conscious, critical, and effective thinking (Beaudry & Miller, 2016). These abilities include students' processes of understanding, evaluating, using scientific knowledge in a social context, and producing effective solutions (McGregor, 2018). Although it is seen that these three basic skills are addressed separately in the existing studies in the literature (Heikkilä & Eriksen, 2023; Langner & Graulich, 2024; Muchlas Abrori et al., 2023; Orhan & Genç, 2024; Shattuck, 2020; Ventistas et al., 2024), it has been limited to evaluate them together and examine their effects on science teachers' professional competences with a holistic approach (Akpan et al., 2023; Allchin et al., 2024). This situation leads to deficiencies in designing policies and strategies to improve science teachers' skills in these areas (Ong et al., 2024). In fact, Çıldır and Acarlı (2024) have drawn attention to this gap and made suggestions for science teachers in their research. Therefore, this study aims to fill the knowledge gap in this field by comprehensively examining the correlations between science teachers' research literacy, socio-scientific reasoning, and problem-solving skills. In the research, both quantitative and qualitative data are collected and analyzed by adopting a mixed-method approach (Creswell & Guetterman, 2019). While quantitative research determines the current levels of the subject (Adams & Mcguire, 2023), qualitative research offers an in-depth examination opportunity for researchers (Okoko et al., 2023). At the end of this study, an educational model or strategy proposal is put forward to develop science teachers' research literacy, socio-scientific reasoning, and problem-solving skills. This model aims to provide a concrete guide for teacher training programs, professional development activities, and educational policies. In addition, practical tools and resources are developed to enable science teachers to effectively integrate these skills into the classroom environment. The research findings are expected to provide valuable information for academics, policymakers, curriculum developers, and teachers who contribute to science teacher education. In light of this information, the research questions are presented below.

Research Questions

1) How do teachers perceive and define the correlations among research literacy, socio-scientific reasoning, and problem-solving skills?
2) Do research literacy and socio-scientific reasoning predict problem-solving skills?

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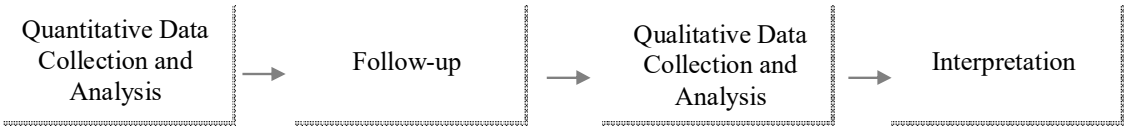
Research Methodology

Design

This study is a mixed-method research that aims to comprehensively examine the correlations among science teachers' research literacy, socio-scientific reasoning, and problem-solving skills. Mixed method research is a research method in which quantitative and qualitative research methods are used together (Creamer, 2025). This method provides a more in-depth and comprehensive analysis by combining different types of data (Mertens, 2023). The study was conducted with the explanatory sequential design of mixed-method research (Fetters, 2020; Johnson & Christensen, 2020). The mixed explanatory sequential design is a mixed method research design in which quantitative data are first collected and analyzed, and then these results are supported by qualitative data and explained in more depth. The model for the research design is given in Figure 1.

Figure 1
Mixed Exploratory Sequential Pattern



The research design starts with the collection and analysis of quantitative data and ends with the interpretation of the qualitative data collection and analysis process with the follow-up phase. The quantitative design of the research is a descriptive survey model. The quantitative descriptive survey is a research design that aims to describe a situation or phenomenon as it is and to describe the current situation with numerical data (Phiri, 2024). The qualitative design of the research is a case study design. A qualitative case study design is a qualitative research design that aims to examine a situation, event, or process in depth and detail (Wahyuni, 2024). The research was conducted between 02 May 2024 and 05 January 2025.

Sampling

The research was conducted in the Karatay, Meram, and Selçuklu districts of Konya province in Türkiye. According to the data obtained from the Konya Directorate of National Education, the number of Science Teachers working in the Karatay district is 138, the number of Science Teachers working in the Meram district is 141, and the number of Science Teachers working in Selçuklu district is 159. There are 438 teachers in total in these three districts. In the calculation made by taking $\alpha = .05$ into account for the quantitative part of the study, if $\pm > 205$ teachers are reached, the sample represents the population (Blair et al., 2023). Accordingly, science teachers in the study population were included in the study by stratified sampling and random sampling technique [Stratification Coefficient: 438/205 = 0.468037; Karatay: ± 66, Meram: ± 67, Selçuklu: ± 74]. Stratified sampling is a sampling technique that involves dividing the population into subgroups (strata) and selecting samples proportionally from each stratum (Hiebert et al., 2023). Random sampling is a completely random sampling technique in which each unit is selected equally and independently (Zou & Xu, 2023). The schools where the teachers work were selected as the sampling unit and the number of science teachers working in these schools was listed. Then, with the help of a computer program, it was decided in which schools the research should be conducted. Then, these teachers were reached on a voluntary basis. In this respect, 31,9% (n = 66) from the Karatay district, 32,4% (n = 67) from the Meram district, and 35,7% (n = 74) from the Selçuklu district participated in the study. The average age of the teachers who participated in the study was 48,75 ± 12,84 and the average professional seniority was 22,14 ± 3,46. Of the Science Teachers participating in the study, 53,6 % (n = 111) were female and 46,4 % (n = 96) were female. In addition, 85,5% (n = 177) of them are Expert Teachers and 14,5% (n = 30) of them are Head Teachers. In the qualitative part of the research, (n = 7) teachers from the field of science (n = 7) in the quantitative part sample were selected on a voluntary basis. In the selection of teachers, a purposeful sampling sub-sample criterion sampling technique was used. In the selection of science teachers, *"being on active duty at least in the title of expert or head teacher and having a professional seniority of twenty years or more"* were determined as criteria. Qualitative purposive sampling

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is a sampling technique in which participants who are most appropriate for the research questions and who can provide information are consciously selected (Savin-Baden & Major, 2022). This research was conducted with the decision taken by Akdeniz University Social and Human Sciences Scientific Research and Publication Ethics Committee on 16.11.2024 with the number 26.

Data Collection Tools

In the quantitative part of the study, the research literacy skills scale consisting of twenty-six items developed by Yıldız et al. (2019), the socio-scientific reasoning skills scale consisting of eighteen items developed by Çıldır and Acarlı (2024), problem-solving skills scale consisting of eighteen items developed by Yaman and Dede (2008) were used. The high scores obtained from research literacy, socio-scientific reasoning, and problem-solving skills scales indicate that teachers have strong abilities and skills in these areas. All of the scale items were positive and were subjected to the classification of '1- Strongly Disagree, 5-Strongly Agree' and applied face-to-face. Confirmatory factor analysis and reliability analyses were performed for the scales. Research literacy skills scale CMIN/DF 1.467, *p*-value .185, RMSEA value .048, SRMR value .009, CFI value, .959, GFI value .986; socio-scientific reasoning skills scale CMIN/DF 1.467, *p*-value. 185, RMSEA value .048, SRMR value .009, CFI value, .959, GFI value .986; problem solving skills scale CMIN/DF 2.055, *p*-value .017, RMSEA value .072, SRMR value .014, CFI value, .984, GFI value .970. These values confirmed the validity of the measurement tools (Chen & Yung, 2023; Newsom, 2024). Research literacy skills scale McDonald's omega ω=.780, socio-scientific reasoning skills scale McDonald's omega ω=.831, problem-solving skills scale McDonald's omega ω=.811. These values showed that the measurement tools were reliable (Cipresso & Immekus, 2022). In the qualitative part of the study, a semi-structured interview form was developed. Semi-structured interview form is a research technique used to collect information about a specific topic (Denzin & Lincoln, 2018; Flick, 2022). The interviews with the participants lasted approximately forty to seventy minutes. The interviews with the participants were conducted in a sincere environment, and the answers to the questions were deepened with 'Why?' and 'How?' questions. The interviews were audio-recorded with participants' written consent. In qualitative research, validity and reliability are approached differently than in quantitative research. Credibility ensures accuracy, transferability assesses applicability, reliability evaluates consistency, and confirmability establishes impartiality. The researcher's field notes, serving as self-reflexive diaries, support the hermeneutic interpretation of data, which is essential for understanding participants' perspectives and experiences (Gunbayi, 2024). From this point of view, validity refers to the accuracy of the research and reliability refers to its consistency. In this research, these concepts were achieved by analyzing the data in depth and contextually. The interview transcripts regarding the validity and reliability of qualitative analyses are given in the sub-sections of the theme analysis.

Data Analysis

Linearity, multiple linear connections, multiple normality, and independence assumptions were tested for the measurement tools (Frey, 2018). These assumptions of the measurement tools were verified. In the study, reference values for skewness and kurtosis values were determined as ±3 (Denscombe, 2020). Accordingly, the skewness value of the research literacy skills scale was -.491, kurtosis value was .632; the skewness value of the socio-scientific reasoning skills scale was -1.636, kurtosis value was 2.448; the skewness value of the problem-solving skills scale was -1.504, kurtosis value was 2.623. These values showed that the measurement tools were normally distributed (Crano et al., 2023). JAMOVI 2.4.2 package program was used in the quantitative part of the study. After determining that the data were normally distributed, Pearson correlation analysis was performed. Then, regression analysis was performed for the prediction of problem-solving by research literacy and socio-scientific reasoning. The assumptions of the regression analysis were made and given under the relevant table. Qualitative analyses were conducted with the NVIVO 14 package program concerning Gunbayi (2023). The data obtained from in-depth interviews with teachers were first transcribed and then subjected to a qualitative data analysis process. In the first step, the interviews were recorded and transcribed verbatim. The transcripts were read repeatedly to get a preliminary idea about the general structure and content of the data. In the second step, after the initial review of the data, the content analysis method was used to identify important statements, concepts, and themes in the data. In the third step, the codes were grouped according to their similar characteristics, and categories were formed. At this stage, the correlations and thematic connections between codes were analyzed. In the fourth step, themes were formed by analyzing the correlations between categories and general trends. At this stage, it was analyzed how the categories were related to each other and how they answered the research

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questions. In the last step, to ensure the reliability of the analysis process, the codes, categories, and themes were discussed among the researchers, and the consensus points were determined. In addition, to test the consistency of the findings, some of the data were analyzed by five independent researchers, and the results were compared. Fleiss Kappa reliability coefficient $K = .853$ $p = .001$ was calculated for the data at the end of the study. This value showed that the level of reliability between the practitioners was high (Gwet, 2021). Ethically, the names of the participants were coded as *"A, B, C, D, E, F, G".*

Research Results

Quantitative Results

Information about the distribution levels of teachers' perceptions of research literacy, socio-scientific reasoning, and problem-solving skills and the correlation between research literacy, socio-scientific reasoning, and problem-solving skills are given in Table 1, and information about whether research literacy and socio-scientific reasoning predict problem-solving skills is given in Table 2.

Table 1
Descriptive statistical analysis results regarding the distribution levels of measurement tools

Scales	Y_1	Y_2	Y_3	*M*	*SD*
Research Literacy (Y_1)	1			4.13	0.236
Socio-Scientific Reasoning (Y_2)	.431**	1		4.10	0.294
Problem-Solving (Y_3)	.700**	.870**	1	4.14	0.276

**p < .05; ** p < .01; *** p < .001, N = 207*

When Table 1 is analyzed, it is seen that the participants had high levels of research literacy ($M = 4.13$, $SD = 0.236$), socio-scientific reasoning ($M = 4.10$, $SD = 0.294$), and problem-solving ($M = 4.14$, $SD = 0.276$). Correlation analyses show that there are statistically significant positive correlations between research literacy and socio-scientific reasoning ($r = .431$, $p < .01$), research literacy and problem-solving ($r = .700$, $p < .01$), and socio-scientific reasoning and problem-solving ($r = .870$, $p < .01$). These findings indicate that there is a strong correlation between the three variables.

Table 2
Results of regression analyses on research literacy and socio-scientific reasoning predicting problem-solving skills

Variables	β	*SE*	*t*	*p*	R^2	Problem-Solving (Ŷ)	
						Tolerance	VIF
Research Literacy (X_1)	.400	,031	15.292	.001***	.887	.814	1.228
Socio-Scientific Reasoning (X_2)	.697	.024	26.681	.001***			

**p < .05; ** p < .01; *** p < .001, N = 207, Beta coefficient values are given as standardized. R value was .942, R^2 value was .887, adjusted R^2 value was .887, $F_{(2\text{-}204)} = 796.862$, Durbin Watson value was 1.791.*

According to Table 2, research literacy (β = .400, $p < .001$) and socio-scientific reasoning (β = .697, $p < .001$) significantly and positively affect problem-solving skills. The regression model explained 88.7% of the variance in problem-solving ($R^2 = .887$) and the appropriateness of the model was supported by $F_{(2, 204)} = 796.862$, $p < .001$. These findings indicate that both variables play a strong determinant role in problem-solving.

Qualitative Results

Information on how science teachers perceive and define the correlations between research literacy, socio-scientific reasoning, and problem-solving skills are given in Table 3, Table 4, and Table 5.

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Table 3
Theme Analysis for the İdentification of Research Literacy, Socio-scientific Reasoning, and Problem-solving Skills

Theme	Category	Code	Participants
Research Literacy Skills	Scientific Process and Critical View	Research literacy is the ability of students to understand and apply scientific research processes and to look critically at information.	A, B, C, D, E, F, G
	Data Collection and Analysis	Research literacy includes the ability to collect and analyze data.	A, B, E, F, G
Socio-Scientific Reasoning Skills	Social and Ethical Context	Socio-scientific reasoning is the ability to understand society in the context of ethical values.	A, B, E, F, G
	Social and Ethical Evaluation	Socio-scientific reasoning is the ability to evaluate scientific knowledge in a social and ethical context.	C, D, G
Problem-solving Skills	Identification, Analysis and Solution Generation	Problem-solving skills are the ability to identify, analyze, and produce effective solutions to problems encountered.	A, B, C, D, E, F, G
	Creative and Strategic Thinking	Problem-solving skills include the capacity for creative thinking and strategic planning.	B, F, G

When Table 3 is analyzed, information on how science teachers define research literacy, socio-scientific reasoning, and problem-solving skills is given below.

In line with the teachers' views, it was determined that research literacy includes skills such as looking critically at scientific knowledge, accessing knowledge using scientific methods, collecting and analyzing data, and reading and understanding scientific literature. For example, one teacher emphasized the importance of students' understanding and application of scientific research processes and said: *"...it is important for students to understand and apply scientific research processes. Thus, they can question scientific knowledge and make their decisions accordingly." [A].* Similarly, another teacher stated that research literacy provides the ability to use scientific methods effectively: *"...research literacy provides the ability to use scientific methods effectively." [B].* In addition, one of the teachers stated that students should be able to read and understand scientific literature and generate new knowledge: *"...students should be able to read and understand scientific literature and generate new knowledge." [C].*

Teachers stated that socio-scientific reasoning includes skills such as evaluating scientific knowledge in a social and ethical context, applying scientific knowledge in daily life, and making moral and logical decisions. For example, one teacher emphasized the importance of analyzing scientific knowledge in correlation to social problems: *"...it is very important to be able to analyze scientific knowledge in correlation to social problems." [D].* Another teacher stated that students should be able to make ethical evaluations about scientific issues: *"...students should be able to make ethical evaluations about scientific issues." [E].* Moreover, one teacher stated that discussing the ethical aspects of scientific developments in society enables students to think critically: *"...discussing the ethical aspects of scientific developments in society enables students to think critically." [F].*

Teachers emphasized aspects of problem-solving skills such as defining and analyzing the problem, generating solutions using scientific methods, and strategic and creative thinking. For example, one teacher stated that students should solve the problems they encounter by using scientific methods: *"...students should solve the problems they face by using scientific methods." [G].* Another teacher emphasized that problem-solving skills require creative thinking and strategic planning: *"... problem-solving skills require students to think creatively and make strategic planning." [A].* Moreover, one teacher stated that analyzing complex situations and developing alternative solutions are the basis of this skill: *"... analyzing complex situations and developing alternative solutions is the basis of this skill." [F].*

Table 4
Theme Analysis of the Link between Research Literacy, Socio-scientific Reasoning and Problem Solving Skills

Theme	Category	Code	Participants
Research Literacy Skills	Access and Use of Scientific Knowledge	Research literacy increases students' access to scientific knowledge and their ability to use this knowledge.	A, B, F
	Critical View of Knowledge	Research literacy provides students with the ability to acquire and evaluate scientific knowledge.	C, D, G

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Theme	Category	Code	Participants
Socio-Scientific Reasoning Skills	Evaluation in Social and Ethical Context	Socio-scientific reasoning enables students to evaluate scientific knowledge in a social and ethical context.	A, B, E, F
	Social and Ethical Perspective	Socio-scientific reasoning enables evaluating knowledge within social and ethical contexts.	C, D, G
Problem-solving Skills	Generating Creative and Effective Solutions	Problem-solving skills enable students to use the acquired knowledge to solve real-world problems.	A, B, E, F, G
	Use of Scientific Method	Problem-solving skills involve generating creative, scientific solutions.	C, G

When Table 4 is analyzed, information about the connection between science teachers' research literacy, socio-scientific reasoning, and problem-solving skills is given below.

Under the theme of research literacy skills, teachers emphasized students' skills in accessing and using scientific knowledge and developing a critical perspective. Teachers stated that research literacy increases students' ability to access and use scientific knowledge. For example, one teacher stated that *"...research literacy facilitates students' access to scientific knowledge and enables them to use this knowledge in a meaningful way." [A]*. Similarly, another teacher drew attention to the importance of the ability to use scientific sources correctly and stated, *"... the ability to use scientific sources correctly is a critical point in students' research." [B*]. Moreover, one of the teachers emphasized the importance of students' reaching meaningful information by examining scientific literature: *"... students' access to meaningful information by analyzing scientific literature is an important part of research literacy." [F]*. Teachers stated that research literacy is not only limited to accessing information but also provides the ability to critically evaluate this information. For example, one teacher stated that *"...students should not only access scientific knowledge but also question its reliability." [C]*. Another teacher emphasized the importance of analyzing scientific knowledge and distinguishing correct knowledge and stated, *"... analyzing scientific knowledge and distinguishing correct and incorrect knowledge is the basis of research literacy." [D]*. Moreover, one teacher stated that a critical perspective enables students to be conscious individuals: *"...evaluating scientific knowledge from a critical perspective enables students to become more conscious individuals." [G]*.

Under the theme of socio-scientific reasoning skills, teachers emphasized that students should have the ability to evaluate scientific knowledge in an ethical and social context. Teachers stated that students should be able to evaluate scientific knowledge not only academically but also in a social and ethical context. For example, one teacher stated, *"...it is important to be able to evaluate the social consequences of using scientific knowledge." [A]*. Another teacher emphasized the necessity of analyzing the effects of scientific developments on society: *"... students should be able to analyze the effects of scientific developments on society." [B]*. Moreover, one teacher stated that scientific ethics enables students to evaluate their decisions within an ethical framework: *"...scientific ethics enables students to evaluate their decisions within an ethical framework." [E]*. Teachers stated that socio-scientific reasoning develops students' ability to consider scientific knowledge in the context of ethical and social issues. For example, one teacher said, *"...it is important not only to learn scientific knowledge but also to evaluate its social implications." [C]*. Another teacher emphasized that students should approach scientific knowledge knowing their ethical responsibilities: *"...students should approach scientific knowledge knowing their ethical responsibilities." [D]*.

Under the theme of problem-solving skills, teachers emphasized that students should be able to produce creative and effective solutions using scientific methods. Teachers stated that problem-solving skills are not only based on technical knowledge but also require creative and strategic thinking. For example, one teacher stated, *"... students should be able to apply the knowledge they have learned to real-life problems." [A]*. Another teacher emphasized the importance of transforming scientific knowledge into practical solutions: *"...scientific knowledge should not only be learned theoretically but should also be transformed into practical solutions." [B]*. Moreover, one teacher stated that creative thinking should be encouraged in the problem-solving process: *"...students should be encouraged to think creatively when dealing with complex problems." [G]*. Teachers emphasized that students should be able to produce systematic and logical solutions by using scientific methods in the problem-solving process. For example, one teacher said, *"...scientific methods enable students to generate systematic solutions to the problems they encounter." [C]*. Another teacher stated that scientific thinking supports creative approaches: *"...scientific thinking supports creative approaches in problem-solving." [C]*.

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Table 5
Theme Analysis on the Effect of Research Literacy and Socio-scientific Reasoning on Problem-solving Skills

Theme	Category	Code	Participants
Research Literacy Skills	Access to and Use of Scientific Knowledge	Research literacy develops students' ability to access and use scientific knowledge.	A, B, E, F, G
	Data Collection and Analysis	Research literacy develops students' ability to collect and analyze data and interpret results.	A, B, D
	Decisions based on scientific knowledge	Research literacy enables students to make decisions based on scientific knowledge in problem-solving processes.	C, F, G
Socio-Scientific Reasoning Skills	Social and Ethical Context	Socio-scientific reasoning enables students to evaluate scientific knowledge in a social and ethical context.	A, D, E, F, G
	Social and Ethical Evaluation	Socio-scientific reasoning contributes to students produce more comprehensive and effective solutions by considering social and ethical perspectives.	B, C
Problem-solving Skills	Creating Conscious and Effective Solutions	Problem-solving skills enable students to produce more conscious and effective solutions in problem-solving processes.	A, B, E, F, G
	In-Depth Solutions	Research literacy and socio-scientific reasoning support students to produce more in-depth and conscious solutions in the problem-solving process.	C, D

When Table 5 is analyzed, information about whether science teachers' research literacy and socio-scientific reasoning are effective on problem-solving skills is given below.

Under the theme of research literacy skills, teachers emphasized that students should develop the skills of accessing scientific knowledge, collecting and analyzing data, and making decisions based on scientific knowledge. Teachers stated that research literacy enables students to access scientific knowledge and use this knowledge effectively. For example, one teacher stated that *"...students should know how to access scientific knowledge and be able to use this knowledge in their own research." [A]*. Similarly, another teacher stated that research literacy teaches access to scientific resources and correct use of information: *"...research literacy teaches accessing scientific resources and using information correctly."* [B]. Moreover, one teacher emphasized that access to scientific knowledge encourages students' inquisitive and analytical thinking: *"...access to scientific knowledge encourages students' inquisitive and analytical thinking." [G]*. Teachers stated that research literacy develops students' skills in collecting and analyzing scientific data and interpreting the results. For example, one teacher stated that *"...collecting and analyzing scientific data is one of the most critical steps in the research process." [A]*. Another teacher stated that students should draw meaningful conclusions by analyzing data: *"...students should not only access information but also analyze data and draw meaningful conclusions." [B]*. Teachers stated that research literacy enables students to make decisions based on scientific knowledge in problem-solving processes. For example, one teacher stated that *"...making decisions based on scientific knowledge develops students' critical and conscious thinking skills." [C]*. Another teacher emphasized that decisions based on scientific knowledge improve the quality of the problem-solving process: *"...making decisions based on scientific knowledge improves the quality of the problem-solving process." [G]*.

Under the theme of socio-scientific reasoning skills, teachers emphasized that students should have the ability to evaluate scientific knowledge in an ethical and social context and to produce effective solutions by considering social and ethical perspectives. Teachers stated that socio-scientific reasoning provides the ability to evaluate scientific knowledge in a social and ethical context. For example, one teacher said, *"...students should consider social and ethical aspects when evaluating scientific knowledge." [A]*. Another teacher stated that scientific ethics enables students to evaluate scientific developments more comprehensively: *"...scientific ethics allows students to evaluate scientific developments more comprehensively." [E]*. Teachers stated that it contributed to students producing more comprehensive and effective solutions by considering social and ethical perspectives. For example, one teacher stated, *"...evaluating scientific knowledge with ethical and social aspects enables students to make more informed decisions." [B]*. Another teacher emphasized that understanding the correlation between society and science encourages students to think critically: *"...understanding the correlation between society and science encourages students to think critically." [C]*.

Under the theme of problem-solving skills, teachers emphasized that students should acquire the skills to produce conscious and effective solutions and to develop in-depth solutions using scientific methods. Teachers stated that problem-solving skills enable students to produce more conscious and effective solutions. For example,

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one teacher said, *"...students should produce conscious and effective solutions to the problems they encounter by using scientific methods." [A].* Another teacher emphasized that using scientific knowledge increases the quality of producing solutions: *"...using scientific knowledge in the problem-solving process increases the quality of producing solutions." [B].* Teachers stated that research literacy and socio-scientific reasoning support the generation of more in-depth and conscious solutions in the problem-solving process. For example, one teacher stated that *"...students should produce comprehensive solutions by combining scientific knowledge and ethical values." [C].* Another teacher stated that scientific methods enable students to make more in-depth analyses: *"...scientific methods enable students to make more in-depth analyses and produce effective solutions to problems." [D].*

Discussion

In this study, the correlation between research literacy, socio-scientific reasoning, and problem-solving skills was analyzed, along with the predictive effects of these skills on problem-solving, using both quantitative and qualitative methods. The findings revealed significant and positive correlations among these three skills. These results align closely with existing studies in the literature, emphasizing their interdependent nature, particularly within the framework of 21st-century skills (Bentz et al., 2024; Dhakal, 2022; Evans, 2017; Gutman & Genser, 2017; Izumi-Taylor, 2023; Ngu et al., 2024; Romine et al., 2020; Waring, 2017). Quantitative analyses indicated a significant correlation between research literacy and socio-scientific reasoning. Moreover, both research literacy and socio-scientific reasoning were found to be significant predictors of problem-solving skills. These findings align with previous studies suggesting that students' ability to critically access and evaluate scientific knowledge enhances their capacity to draw logical inferences within social and ethical contexts (Chang et al., 2018; Evans et al., 2017; Varlik, 2024). However, while most existing studies examine these correlations from a descriptive and confirmatory perspective, in-depth analyses of causal relationships remain limited. Qualitative findings further reinforce this correlation. Science teachers emphasized that research literacy serves as the foundational building block for socio-scientific reasoning skills, a perspective consistent with prior research (Filho et al., 2024; Shank et al., 2018). These findings underscore the need for a holistic approach to the simultaneous development of these two competencies in educational settings. One of the key insights from this study is the positive effect of research literacy on problem-solving skills. The high standardized β coefficient observed in the quantitative analyses highlights the strength of this relationship. Research literacy enhances students' ability to generate solutions based on scientific knowledge, thereby fostering the development of creative and effective strategies in the problem-solving process (Beaudry & Miller, 2016; Dhakal, 2022; Heikkilä & Eriksen, 2023). This finding aligns with studies that position research literacy as a central pillar of education (Adams, 2024; Johnson, 2024; McGregor, 2018; Ong et al., 2024). Despite these findings, existing studies often fail to examine in detail which variables amplify or diminish these interactions. This suggests that the impact of research literacy may vary across different learning environments or student demographics. Furthermore, there is limited evidence regarding the contribution of research literacy to problem-solving in interdisciplinary contexts, particularly within the social sciences. This raises the question of whether research literacy exerts a uniform effect across diverse academic domains. One of the most striking findings of this study is the impact of socio-scientific reasoning on problem-solving skills. The very high correlation coefficient and standardized β coefficient indicate that socio-scientific reasoning is a strong determinant of problem-solving ability. Teachers' perspectives corroborate this finding, as they assert that socio-scientific reasoning enhances students' capacity to evaluate complex problems within social and ethical contexts. This conclusion is consistent with prior research (Allchin et al., 2024; Attri, 2018; Filho et al., 2024; Langner & Graulich, 2024; Sadler, 2021; Ventistas et al., 2024; Zheng, 2023). Moreover, this finding suggests that students should not only develop technical competencies but also cultivate ethical and social responsibility (Abell, 2007; Uyanık, 2024). However, from a critical standpoint, it is essential to recognize that correlation does not imply causation. For instance, does socio-scientific reasoning directly enhance problem-solving skills, or is it possible that individuals with advanced problem-solving abilities naturally excel in socio-scientific reasoning? The directionality of this relationship remains a point of debate in the literature. While previous studies indicate that socio-scientific reasoning contributes to students' problem-solving processes, they do not sufficiently explore whether this correlation is independent of prior academic background or cognitive abilities. Incorporating variables such as individual differences and prior academic achievement into future research methodologies could yield more precise insights into the nature of this relationship. Science teachers in this study conceptualized research literacy, socio-scientific reasoning, and problem-solving skills as interdependent and mutually reinforcing competencies. Research literacy is defined as students' ability to understand scientific processes, adopt a critical perspective, and apply scientific methods

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(Johnson, 2024; Sambey, 2016). Socio-scientific reasoning entails the capacity to assess scientific knowledge within social and ethical contexts (Knain, 2015), while problem-solving skills encompass the ability to identify (Zheng, 2023), analyze (Hiremath, 2024), and generate creative and strategic solutions (Musa, 2024). The synergy among these skills enables students to apply scientific knowledge effectively to real-life challenges (Akpan et al., 2023; Seher Budak & Defne Ceyhan, 2023). Research literacy fosters the ability to access and critically evaluate scientific information (Menard, 2003), while socio-scientific reasoning facilitates the application of this knowledge to social issues and ethical dilemmas (Abell, 2007; Uyanık, 2024). Problem-solving skills integrate these competencies, enhancing students' capacity to devise innovative and practical solutions (Beghetto, 2018; Ngu et al., 2024). Teachers emphasized that these three skills are crucial for students' cognitive development and academic success. This perspective is supported by prior research (Adams, 2024; Finnegan, 2024; Gillies, 2024; Ong et al., 2024). However, an ongoing challenge is how to integrate these competencies more effectively within educational curricula. Although existing studies highlight the necessity of developing these skills in tandem, educational systems often treat research literacy and socio-scientific reasoning as separate domains. Consequently, students typically acquire these skills in a theoretical rather than applied context. This suggests that traditional pedagogical approaches may be insufficient in fostering these competencies and that problem-centered or interdisciplinary strategies may be more effective. Furthermore, compared to existing literature, there is a need for further research on how these correlations respond to contextual variables, individual differences, and interdisciplinary considerations. Specifically, the nature and mechanism of socio-scientific reasoning's impact on problem-solving skills warrant more in-depth investigation. Additionally, practical recommendations should be developed for effectively integrating these skills into educational and training programs.

Conclusions and Implications

This study examined the levels of research literacy, socio-scientific reasoning, and problem-solving skills, along with their intercorrelations and effects on problem-solving abilities. The findings indicated that all three skills were highly developed among participants and demonstrated significant positive correlations with each other. Regression analyses further revealed that both research literacy and socio-scientific reasoning had significant positive impacts on problem-solving skills, with socio-scientific reasoning showing a particularly strong effect. These results highlight the critical role of these three skills in enhancing students' scientific and analytical thinking capacities, as they mutually reinforce one another. The study underscores the necessity of considering research literacy, socio-scientific reasoning, and problem-solving skills as an integrated whole in students' cognitive development. Not only do these skills foster scientific knowledge and critical thinking on an individual level, but they also facilitate the application of scientific understanding within social and ethical contexts. Socio-scientific reasoning, in particular, serves as a vital bridge between comprehending and applying scientific knowledge, while problem-solving skills empower students to devise creative and effective solutions to real-world challenges. These findings support the theoretical significance of an integrated skills approach in education. Based on these insights, adopting a holistic strategy for developing these three skills is essential for shaping educational policies and teaching methodologies.

In science curricula, greater emphasis should be placed on activities that enhance research literacy, discussions centered on socio-scientific issues, and creative problem-solving tasks. Teachers should be adequately trained and equipped with the necessary expertise to guide students in cultivating these competencies. Additionally, implementing innovative pedagogical approaches such as interdisciplinary activities and problem-based learning is expected to facilitate meaningful connections between these skills. In this context, it is imperative to incorporate research literacy, socio-scientific reasoning, and problem-solving skills into a cohesive framework within curriculum design and teacher education programs. This study has demonstrated the crucial role of these competencies in both individual and societal contexts, offering both theoretical insights and practical recommendations for fostering their development.

Recommendations

The findings of this study provide important insights for the design of educational programs. The strong intercorrelation between research literacy, socio-scientific reasoning, and problem-solving skills underscores the need for an integrated instructional approach. To equip students with the ability to navigate both scientific and societal challenges, educational programs should be restructured to cultivate these skills cohesively. Teacher training should be enhanced with targeted content on the pedagogy and assessment of these competencies. Furthermore,

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interdisciplinary approaches and student-centered learning strategies should be prioritized, with an emphasis on real-world problem-solving activities. The integration of technology and digital tools into teaching and learning processes should be strengthened, and assessment methods should be diversified to include process-oriented and performance-based evaluations. At the policy level, national strategies should be developed to foster these essential skills, ensuring that schools provide supportive and resource-rich learning environments.

Limitations

In this study, the combination of quantitative and qualitative data increased the depth of the findings. However, the fact that the study was limited to science teachers is a limitation in terms of generalizability. Conducting similar studies with teachers and students from different branches in future studies may expand the scope of the findings. In addition, the development processes and long-term effects of these skills can be examined in more detail by using longitudinal designs.

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